HEALTH CONSULTATION

VALLEY PIKE VOC SITE

RIVERSIDE, MONTGOMERY COUNTY, OHIO

EPA FACILITY ID: OHN000510923

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Prepared by:

The Health Assessment Section
of the Ohio Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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SUMMARY

Introduction

The Valley Pike VOC Site is located in a residential neighborhood in Riverside, Montgomery County, Ohio. The volatile organic compounds (VOCs) tetrachloroethylene (PCE) and trichloroethylene (TCE), chlorinated solvents commonly used in industrial degreasing processes, were detected in the groundwater adjacent to an active manufacturing facility. These chemicals are vaporizing off of the groundwater under residences to the west and southwest of the facility and migrating up through soils as soil gas and then entering the indoor air in area homes through a process known as vapor intrusion.

This health consultation summarizes the results of U.S. Environmental Protection Agency (US EPA) sampling of subsurface soil gas and the indoor air of the homes affected by the Valley Pike VOC plume as of July 3, 2014.

Conclusions

The Agency for Toxic Substances and Disease Registry and the Health Assessment section of the Ohio Department of Health (ODH) arrived at three conclusions regarding the Valley Pike VOC site.

Conclusion 1

A completed exposure pathway exists for the inhalation of indoor air contaminants which might be entering homes via vapor intrusion and the full extent of the impact on homes in this area has not yet been defined. Sampling of additional homes is necessary to determine whether additional residents may be exposed to chemicals in their indoor air at levels that may pose a health concern.

Basis for Decision

PCE and TCE have been detected in high concentrations in the groundwater, soil gas, sub-slab soil gas, and indoor air in and around homes to the west of the Mullins Rubber Products facility, indicating that vapor intrusion is occurring or could occur. Only about half of the homes potentially impacted by contaminated groundwater have been sampled.

Conclusion 2

Breathing indoor air contaminated with PCE in the affected area over the course of a lifetime could adversely impact the health of residents.

Basis for Decision

PCE concentrations in the indoor air of fifteen out of 95 homes sampled exceeded the U.S.EPA reference concentration (RfC) of 5.9 ppb; the sub-slab soil gas concentrations of 81 out of 190 homes sampled exceeded the RfC.

Furthermore, the indoor air of 32 homes exceeded the ATSDR Cancer Risk Evaluation Guide (CREG) of 0.57 ppb. The CREG is equivalent to a risk of one excess cancer per million individuals, and is not considered an elevated risk. U.S. EPA has identified the need for time critical action in homes whose indoor air concentrations correlate with an increased risk of greater than 1 in 10,000

people (or "10^{-4} cancer risk") *above background cancer risk* ***over a lifetime of exposure***. For PCE, the 10^{-4} cancer risk EPA action level is 57 ppb. In this community, six homes exceeded 57 ppb in indoor air. Because only about half the homes in the impacted area have been sampled, others could also exceed the target risk range.

Six homes sampled to date have concentrations of PCE that pose an elevated cancer risk in indoor air, thus PCE exposure poses a public health hazard in this community.

Conclusion 3

Breathing indoor air contaminated with TCE in the affected area could be harmful.

Basis for Decision

Potential adverse health effects from breathing TCE include immunological effects, fetal heart malformations, kidney toxicity, and an increased risk of developing kidney cancer. TCE concentrations detected thus far in the indoor air are mostly below levels of health concern. However, TCE levels in the ambient air of eight homes exceeded the U.S EPA Region 9 Interim TCE Indoor Air Response Action Level of 1.1 ppb. This action level is based on studies of congenital heart deformities observed in developing fetuses with mothers exposed to TCE within the first few weeks of birth.

The lower detection limit of TCE for this analysis exceeded the ATSDR CREG of 0.045 ppb. Thus, all 30 detected concentrations exceeded the CREG. U.S. EPA has identified the need for time critical action in homes whose indoor air concentrations correlate with an increased risk of greater than 1 in 10,000 people (or "10^{-4} cancer risk") *above background cancer risk* ***over a lifetime of exposure***. For TCE, the 10^{-4} cancer risk action level is 3.7 ppb. In this community, one home's TCE level of 4.36 ppb in indoor air exceeds this concentration. Since only about half the homes in the impacted area have been sampled, others could also exceed the target risk range.

Eight homes sampled to date have concentrations of TCE in indoor air that exceed cancer and non-cancer health concern levels, thus TCE exposure poses a public health hazard in this community.

Next Steps

The U.S. EPA plans to continue to conduct vapor intrusion sampling in the residential neighborhood to determine the full extent of the contamination. Homes with elevated levels of PCE or TCE may be offered a sub-slab vapor abatement system to mitigate or eliminate the vapor intrusion hazard.

For More Information

If you have any concerns about your health, as it relates to exposure to the chemicals of concern at this site, you should contact your health care provider.

More information about this site is available at U.S. EPA's web page, available at: http://www.epaosc.org/site/site_profile.aspx?site_id=8623.

PURPOSE AND STATEMENT OF ISSUES

The Valley Pike site is a vapor intrusion site which consists of a community overlaying a trichloroethylene (TCE) and tetrachloroethylene (PCE) groundwater plume along Valley Pike in Dayton, Ohio. This health consultation is a follow up of a Letter Health Consultation written by the Ohio Department of Health in March of 2014 in response to a request for technical public health assistance from the United States Environmental Protection Agency (U.S. EPA).

In June 2013, U.S. EPA had requested that ODH identify screening and action levels for PCE and TCE in sub-slab and indoor air samples in the community. Screening levels provided by ODH were based on a 10^{-5} cancer risk and U.S. EPA's reference concentration (RfC) for non-cancer effects. Action levels provided by ODH were based on a 10^{-4} cancer risk and the non-cancer RfC multiplied by 10. Both screening and action levels were calculated by ODH as recommended in the U.S.EPA Region 5 Vapor Intrusion Guidebook (2010). The sub-slab soil gas screening levels were derived by multiplying the indoor air levels by 10, assuming an attenuation factor of soil gas through building structures of 0.1.

Between July 8 and July 25, 2013, the U.S. EPA conducted a Vapor Intrusion Investigation at the site including sampling of groundwater, soil gas, residential sub-slab soil gas, and indoor air. Very high concentrations of PCE and TCE have been detected in groundwater and soil gas. Indoor air in a number of homes has also demonstrated varying levels of these pollutants indoors, which shows the gas is successfully migrating from the contaminated groundwater into indoor air (i.e., "*a completed exposure pathway*"). Many indoor air levels exceeded health based screening criteria, and some exceeded action levels for one pollutant or the other, or both.

Letter Health Consultation

Between July 8 and July 25, 2013, the U.S. EPA conducted a Vapor Intrusion Investigation at the site including sampling of groundwater, soil gas, residential sub-slab soil gas, and indoor air. In March 2014, ODH provided the U.S. EPA On-Scene Coordinator (OSC) with final letter health consultation that summarized these results and discussed the public health implications of exposure to volatile organic compounds (VOCs) from vapor intrusion from the site. The first health consultation identified the presence of a completed exposure pathway in the area, connecting the indoor air in area homes with the VOC-contaminated groundwater under the neighborhood via the vapor intrusion pathway. This health consultation summarizes data collected since that time. A complete discussion of the environmental data evaluated and the limitations is presented on page 10 of this health consultation.

Public Meetings

The U.S. EPA held a public meeting for this site at Stebbins High School in Riverside on December 10, 2013 and July 16, 2014 to update residents on progress of the removal action, and to inform the community about the possible health implications of vapor intrusion related exposure. The U.S. EPA OSC presented background information and the environmental sampling results for the site and encouraged homeowners in the areas of concern to sign access agreements with the U.S. EPA to have their homes sampled and if warranted, allow the installation of a vapor mitigation system to reduce the contaminant levels of air within their homes.

BACKGROUND

Site Description and History

The Valley Pike VOC Site is located in a residential neighborhood west and southwest of a potential industrial source located at 2949 Valley Pike, in Riverside, Montgomery County, Ohio. An operational manufacturing facility (Mullins Rubber Products, Inc. (MRP)) primarily produces molded heavy-duty truck/trailer suspension bushings and is located in this mixed industrial and residential area. The facility is bordered to the west by a commercial auto garage, to the east by a single residence and a self-storage facility, to the north by a trucking terminal, and to the south by a mobile home park located on the south side of Valley Pike (Appendix A, Figure 1). Volatile organic compounds (VOCs) are migrating as a contaminant plume off-site in the groundwater under residences located west and southwest of the MRP facility.

The original area of investigation included a residential neighborhood consisting primarily of single-family homes beginning along Hypathia Avenue, roughly 500 feet to the west of the source area and extending to Pleasant Valley Avenue, approximately 1,500 feet to the southwest. The area of concern has been expanded to include an additional block to the southwest beyond Broadmead Avenue (Appendix A, Figure 1). Groundwater contaminants have not been detected west of Prince Albert Boulevard (Appendix A, Figure 2). The Valley Pike neighborhood is being affected by the subsurface migration of vapor-phase chemicals from the groundwater surface to the indoor air in area homes, a process known as vapor intrusion.

Area Geology and Hydrogeology

The immediate area surrounding the MRP facility is underlain by more than 100 feet of interbedded sand, gravel, and clay soils. Porous and permeable gravel soils occur at depths from 0–35 feet below the ground surface (bgs) (Ohio Department of Natural Resources well logs). The local water table (or the groundwater surface) is roughly 20–25 feet bgs (Ohio EPA, 2013). Groundwater in this area flows to the west-southwest.

Demographics

Riverside is a city in northeastern Montgomery County, Ohio. It is part of the Dayton Metropolitan Statistical Area. Based on the 2010 census, Riverside has a population of 25,201. By race, the population of Riverside is 87.2 percent White, 6.6 percent Black, 0.3 percent Native American, 1.9 percent Asian, 1.1 percent some other race, and 2.8 percent two or more races. About 3.3 percent of the population is Hispanic or Latino (of any race). The city has a total of 10,284 households and 6,696 families.

Contaminants of Concern

The Ohio Environmental Protection Agency (Ohio EPA) reported in 2013 that the PCE (tetrachloroethylene) and TCE (trichloroethylene) chlorinated solvents used in industrial degreasing processes, were detected in area groundwater along Valley Pike. PCE was detected as high as 14,000 parts per billion (ppb) from a shallow groundwater monitoring well #14 located on the garage property. Groundwater flow in the area is to west-southwest (Ohio EPA, 2013). PCE was detected at 1,500 ppb and TCE was estimated at 23 ppb in monitoring well #4, located on Hypathia Avenue, 850 feet west of the suspected source area, near residential properties. Ohio

EPA speculated that there was a release of PCE from either the manufacturing facility or the immediately adjacent garage property (Ohio EPA, 2013).

DISCUSSION

Exposure Pathways

In order for residents to be exposed to chemical contaminants, they must come into direct contact with the contaminants through a completed exposure pathway. A completed exposure pathway consists of five main parts:

1. A **Source** of contamination (a chemical release, landfill, etc.),
2. A method of **Environmental Transport** (air, water, soil, sediment, etc.), which allows the chemicals to move from the source area and bring it into contact with people,
3. A **Point of Exposure** is where people come into physical contact with the chemicals,
4. A **Route of Exposure** (ingestion, inhalation, or dermal contact), which is how people come into contact with chemicals, and
5. A **Population at Risk**, i.e., people likely to come into contact with site-related chemicals.

Physical contact with a chemical contaminant alone does not necessarily result in adverse health effects. A chemical's ability to affect a person's health depends on:

- How much of the chemical a person is exposed to (dose)
- How long a person is exposed (duration)
- How often a person is exposed (frequency)
- The toxicity of the chemical (how chemicals can make people sick)

Other factors affecting a chemical's likelihood of causing adverse health effects upon contact include the resident's

- personal habits,
- diet,
- age and sex,
- current health status, and
- past exposures to toxic chemicals (occupational, hobbies, etc.).

Groundwater Pathway

Groundwater is water that occurs below the surface of the earth in pore-spaces in rock layers and soil deposits. Groundwater supplies water to wells and springs and is a substantial source of the drinking water used in the United States. About 3½ million Ohioans or thirty percent of the Ohio population, drink water from a community water system that uses groundwater as its source (U.S. EPA 2009). Prior to the 1960s, most homes in the Riverside area used private wells as the source of their drinking water (PHDMC, personal communication, 2013). People are not currently drinking this contaminated groundwater and obtain their drinking water from the City

of Dayton public water supply, whose well field is along the Great Miami River roughly 1.5 miles to the northwest of the Valley Pike site. However, some residents may still be using private wells for gardening or other household uses in this area.

Vapor Intrusion Pathway

Vapor intrusion is the movement of vapor-phase volatile chemicals from the underground groundwater and soil into the indoor air of homes and commercial buildings. Vapor intrusion is most likely to occur in buildings located laterally or vertically within 100 feet of volatile subsurface contaminants (U.S. EPA 2002). The detection of PCE and TCE in the sub-slab soil gas under some of the homes to the west of the MRP facility indicated that vapor intrusion is possible and may be occurring. The presence of PCE and TCE in the indoor air of some of these homes confirms that there is a completed pathway of exposure to PCE and TCE via the vapor intrusion route.

Evaluation of Environmental Data

ATSDR develops minimal risk levels (MRLs) based on scientific literature that evaluates exposure to specific pollutants and their associated health effects. To be protective of human health, MRLs have uncertainty factors built into them, and many of these values have been developed to protect the health of all individuals, including sensitive populations (e.g., asthmatics, children, and the elderly).

Based on the MRLs, ATSDR develops media-specific comparison values (CVs) using health-protective exposure assumptions. As a result, ambient air contaminant concentrations lower than their corresponding comparison values are generally considered to be safe and not expected to cause harmful health effects, but the opposite is not true. Because comparison values are often much lower than effect levels, ambient air concentrations greater than comparison values are not necessarily levels of air pollution that would present a possible public health hazard. Rather, chemicals with air concentrations higher than comparison values require further evaluation.

To select the pollutants requiring the most detailed evaluation, ATSDR considered its own health-based comparison values, as well as those published by U.S. EPA. Comparison values were identified for both short-term (acute) and long-term (chronic) exposure durations, and also considered both cancer and non-cancer health effects. In our evaluation, the air sampling results were compared to ATSDR Cancer Risk Evaluation Guides (CREG) and environmental media evaluation guides (EMEGs), and U.S.EPA Reference Concentrations (RfCs). These CVs are defined, below:

- ***ATSDR CREGs*** are concentrations of a carcinogen at which there is a risk for one case of cancer in one million people exposed over a lifetime.
- ***ATSDR EMEGs*** are calculated from ATSDR minimal risk levels (MRLs) for chronic, intermediate, and acute exposures (those occurring longer than 365 days, from between 14-365 days, and 14 days of exposure or less, respectively).

- ***U.S. EPA RfCs*** are estimates of the concentrations of pollutants calculated that anyone could be exposed to for a lifetime without experiencing health effects. RfCs are for inhalational exposures and based on non-cancer health effects.

The underlying premise in this approach is that ATSDR uses comparison values to identify contaminants of concern. These pollutants are reviewed below.

Environmental Sampling Results and Data Limitations

Environmental data are still being collected in the community, and given the volume of samples necessary to evaluate health risks, the data are somewhat limited. Most homes have had one round of sampling, unless they had mitigation systems installed. Those homes have confirmatory sampling to ensure their systems are functioning properly. The remaining homes have a single indoor air or sub-slab sample, which we are assuming represents chronic exposure for the purposes of this evaluation. Ideally, to understand long term exposures, quarterly sampling over a year would be conducted to determine an annual "norm" for each home, which would inform our health conclusion. Thus, a recommendation for seasonal sampling is warranted.

Subslab and Indoor Air Results

As of July 3, 2014, the subsurface, crawlspaces, and indoor air of 190 homes had been sampled in Riverside in the area underlain by the VOC-contamination plume (Appendix A, Figure 1). 24-hour SUMMA canister results are summarized in Table 1, below. At the time this document was drafted, 95 homes had indoor air and/or crawlspace sampling conducted and 120 homes had sub-slab soil gas sampling conducted. Sub-slab results from the impacted neighborhood had detected sub-slab gas levels of PCE up to 27,300 ppb and TCE up to 1,120 ppb. Over 88% (88.3%) of the homes sampled to date by U.S. EPA had sub-slab soil gas with PCE and 60.0% had TCE.

Indoor air levels of PCE have ranged up to 193 ppb and indoor air levels of TCE up to 4.36 ppb, which exceed their respective health based comparison values in indoor air. The non-cancer screening level for PCE is 6 ppb (the U.S. EPA Reference Concentration (RfC)) and the cancer screening level is 0.57 ppb (ATSDR Cancer Risk Evaluation Guide (CREG)); for TCE the EPA RfC adopted by ATSDR as its Minimal Risk Level (MRL) is 0.37 ppb for non-cancer effects and the cancer screening level is 0.045 ppb (CREG). The results of the screening analysis are presented in Table 1.

Approximately 9.5% of the homes tested had indoor air detects of PCE and 31.6% had detections of TCE (see Table 1). It should be noted that the laboratory detection limit used for the TCE analysis is higher than the most conservative ATSDR health based comparison value (the Cancer Risk Evaluation Guide of 0.045 ppb), and that given this limitation it is difficult to characterize how many homes may have TCE at or below the CREG. For the purposes of data evaluation, we assumed non-detected data were actually present at the detection limit for TCE and PCE to be protective of public health.

Most homes with PCE/TCE with the highest concentrations typically had full basements and are clustered at the eastern edge of the neighborhood, closest to the likely groundwater contamination source.

Table 1. Detections of PCE and TCE in Riverside Homes (190 homes tested as of 7/3/2014)†

Chemical	Range of Detections (ppb)	Mean/ Geometric mean (ppb)	Number of Detections	Cancer Comparison Value Type	Number Above Cancer Comparison Values†	Non-cancer Comparison Value Type	Number Above Non-cancer Comparison Values†
Subslab Results							
PCE	0.13-27,300	1252.0/ 13.2	106/120 (88.3%)	5.7 ppb CREG x 10	57/120 (47.5%)	60 ppb RfC x 10 (attenuation factor)	46/120 (38.3%)
TCE	0.13–1,120	46.2/2.1	72/120 (60.0%)	0.45 ppb CREG x 10	65/120 (55.0%)†	3.7 ppb RfC/MRL x 10 (attenuation factor)	47/120 (39.2%)
Indoor air or crawlspace results							
PCE	0.13–193	8.8/0.64	9/95 (9.5%)	0.57 ppb CREG	32/95 (33.7%)	6 ppb RfC	32/95 (33.7%)
TCE	0.13–4.36	0.44/0.26	30/95 (31.6%)	0.045 ppb CREG	119/119 100%†	0.37 ppb RfC/MRL	26/95 (27.4%)

† The detection limit for TCE in this sampling was above the health-based comparison value. To be protective, we assumed all non-detected samples had PCE and TCE present at the detection limit. Therefore, the range and frequency of detections, and the average detection are overestimated. However, as noted in the table, only 9 of the 95 indoor air samples were detected above the comparison value.
*Note that exceeding a Comparison Value does not indicate that health effects will occur. The Comparison Value Screening is used to identify chemicals that need further evaluation of the site-specific exposures to determine if health effects are likely.
CREG – Cancer Risk Evaluation Guide (ATSDR) (corresponds to 10^{-6} cancer risk, no increased risk)
RfC: U.S. EPA Reference Concentration (corresponds to no increased non-cancer risk)
MRL: Minimal Risk Level (corresponds to no increased non-cancer risk)
PCE – tetrachloroethylene
ppb – parts per billion
TCE – trichloroethylene

Groundwater sampling results

Additional groundwater sampling conducted by Ohio EPA in March, 2014 further delineated the extent of the groundwater plume under the neighborhood. Based on this additional sampling, the groundwater contaminant plume appears to be fairly narrow in width (Forest Home Avenue to the north and Valley Pike to the south) and trends nearly due west from the suspected source area along Valley Pike, just east of Hypathia (Figure 2). Groundwater flows from the east to the west parallel to Valley Pike with the highest levels of PCE (up to 20,000 ppb) being immediately west of the likely source area. PCE levels decrease in concentration gradually to the west under the neighborhood with no PCE or TCE being detected in groundwater by the time it reaches Prince Albert Boulevard to the west (Figure 2). One of the residences tested about 300 feet SW of Prince Albert Blvd had sub-slab gas results greater than ODH screening levels (Appendix A, Figure 1). PCE occurs in groundwater at levels as high as 290 ppb in monitoring well GP-4,

located in the distal part of the plume at the corner of Roher Boulevard and Guernsey Dell Avenue (Appendix A, Figure 2). Thus, the area of concern has been defined, but many homes in this area have not been sampled.

Public Health Implications

The primary contaminants of concern at the Valley Pike VOC site consist of the chlorinated solvents PCE and TCE. The evaluation of the potential non-cancer and cancer health outcomes from exposure to these pollutants is presented in this section.

Tetrachloroethylene (PCE)

Tetrachloroethylene (also known as perchloroethylene, PCE or PERC) is a nonflammable liquid at room temperature and is widely used for dry cleaning fabrics and for degreasing metal parts. Other major uses of PCE are as a solvent in some consumer products and in the production of other chemicals. It evaporates easily into the air and has a sharp, sweet-smelling odor. Most people can smell PCE in air at levels in excess of 1,000 parts per billion (ppb). PCE is frequently found in air as well as in groundwater and surface water. It does not appear to bioaccumulate in fish or other animals that live in water. People are typically exposed to PCE from occupational sources, consumer products, and environmental sources (for example, industrial releases). Much of the PCE that gets into surface water and soil evaporates into the air where it is broken down by sunlight into other chemicals or brought back to the soil and water by rain. Because PCE can travel through soils quite easily, it can make its way into underground water, where it may remain for a long time. Under oxygen-poor conditions, bacteria will break down some of the PCE that is in soil and groundwater into breakdown products including trichloroethylene, 1,2-dichloroethylene and vinyl chloride (Vogel and McCarty 1985).

PCE has been recently characterized by the U.S. EPA as “likely to be carcinogenic to humans” by all routes of exposure. Although exposure to PCE has not been directly shown to cause cancer in humans, the U.S. Department of Health and Human Services has determined that PCE may reasonably be anticipated to be a carcinogen (NTP 2011). The International Agency for Research on Cancer (IARC) has classified PCE as a Group 2A carcinogen—probably carcinogenic to humans (limited human evidence, sufficient evidence in animals) (IARC 1995).

PCE was identified as a chemical of concern in contaminated drinking water (along with the chlorinated solvent trichloroethylene) in environmental exposure studies of populations in Woburn, Massachusetts, selected towns in New Jersey, and Camp Lejeune in North Carolina. The Woburn, Massachusetts study (Lagakos et al. 1986) and the New Jersey study (Fagliano et al. 1990) have associated exposure to these chemicals through ingestion of contaminated water with increased levels of leukemia in specific populations within these communities.

- Non-cancer Health Effects

In February 2012, the U.S. EPA established a reference concentration (RfC) of 6 ppb for PCE. The RfC is an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is unlikely to adversely affect health over a lifetime of exposure.

However, exposures to levels above the RfC do not necessarily imply that these exposures will cause non-cancer health effects; further evaluation of the toxicology and exposure scenario is needed. ATSDR has established an acute duration (1–14 days) inhalation minimal risk level (MRL) of 200 ppb and a chronic duration (365 days and longer) inhalation MRL of 40 ppb for PCE, based on neurological effects. An MRL is an estimate of daily human exposure to a substance that is not expected to cause non-cancer health effects during a specified duration of exposure. Likewise, it should be noted that contaminants detected at concentrations that exceed the MRL do not necessarily represent a health threat.

One indoor air sample at a residential property located on Guernsey Dell Avenue in the neighborhood of the Valley Pike VOC site indicated a PCE concentration of 193 ppb, which is above the EPA's RfC of 6 ppb and ATSDR's chronic MRL and is approaching ATSDR's acute MRL. Further evaluation of the studies that are the basis of the RfC and MRLs and the levels at which they reported harmful effects from exposure to PCE was conducted. The levels where adverse health effects may occur, called the lowest observed adverse health effect levels (LOAELs) for PCE, include a LOAEL of 2,200 ppb for neurotoxicity involving color vision and 8,300 ppb for neurotoxicity involving reaction time and cognitive effects (ATSDR, 1997A).

The PCE concentrations measured in residences affected by the Valley Pike groundwater plume exceeded the RfC for chronic exposure in 15 homes, and the chronic ATSDR inhalation MRL of 40 ppb in 6 homes. However, none of the homes had indoor air concentrations of PCE that exceeded LOAELs for neurotoxicity. However, not all homes have been sampled, and many of the homes have only been sampled a single time. Thus, additional sampling is warranted to better define non-cancer risk from PCE exposure to residents of this community.

- Cancer Risk

EPA considers PCE to "likely to be carcinogenic in humans by all routes of exposure." Animal and human data indicate an association between PCE exposure and the development of bladder and liver cancers, non-Hodgkin's lymphoma, and multiple myeloma. The U.S. EPA recently updated its health risk assessment for PCE in February 2012 (U.S. EPA Integrated Risk Information System or IRIS). The inhalation unit risk (IUR) was determined to be 2.6×10^{-7} per $\mu g/m^3$. The IUR is the excess lifetime cancer risk estimated to result from continuous exposure to a substance at a concentration of 1 $\mu g/m^3$ (microgram per cubic meter) in air. Based on the U.S. EPA's IUR, ATSDR has derived a Cancer Risk Evaluation Guide (CREG) of 3.8 $\mu g/m^3$ or 0.57 ppb. CREGs are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime.

Because cancer screening levels for PCE were exceeded in indoor air samples from 32 residences, the cancer risk for an adult resident can be calculated using the U.S. EPA's IUR (2.6×10^{-7} per $\mu g/m^3$) and the PCE concentration detected in the indoor air. The calculation for the home with the highest PCE concentration at this site (193 ppb = 1,309 $\mu g/m^3$) is shown below. Estimates of excess cancer risk are expressed as a proportion of the population that may be affected by a carcinogen during a lifetime of exposure. For example, an estimated risk of 1×10^{-6} predicts the probability of one additional cancer, over background, in a population of 1 million. Cancer risk can be estimated using the equation below:

Cancer Risk = Inhalation Unit Risk x Air Concentration

where,

Cancer Risk = estimated cancer risk (unitless)
Inhalation Unit Risk = $(\mu g/m^3)^{-1}$
Air Concentration = $\mu g/m^3$

Cancer Risk$_{PCE}$-highest measured concentration= 2.6 x 10^{-7} per $\mu g/m^3$ x 1,309 $\mu g/m^3$ = 3.5 x 10^{-4}

This represents about 3+ possible excess cancer cases in a population of 10,000 over a lifetime of exposure. There were 5 other residences besides the one used in the example where the estimated cancer risk exceeded the target risk range of an additional 1 excess cancer case in a population of 10,000 people. The actual or true risk is likely to be less because resident exposure is intermittent and less than a lifetime (70 years). This estimate of cancer risk represents a moderate level of risk; however, it is above the target cancer risk range of 1 x 10^{-4} to 1 x 10^{-6} (1 in 10,000 to 1 in 1,000,000) advised by the U.S. EPA.

Six homes were found to have concentrations of PCE in the indoor air or crawl space that exceeded an estimated lifetime cancer risk of 1 in 10,000 and pose an increased risk for cancer to residents.

Trichloroethylene (TCE)
The primary industrial use of trichloroethylene (TCE) has been the degreasing of metal parts and its use has been closely associated with the automotive and metal-fabricating industries from the 1950's through the 1970's. It is an excellent solvent for removing greases, oils, fats, waxes, and tars. As a solvent it was used alone or blended with other solvents. These solvents were also added to adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners. TCE is also a breakdown product from the biodegradation of PCE in groundwater. When in surface soils, TCE will transform from a liquid to a gas faster than many other VOCs. It has been shown that the majority of the TCE spilled on soils close to the surface will vaporize into the air. When TCE is released into the air, it reacts relatively quickly in the presence of sunlight and oxygen, with about half of it breaking down to simpler compounds in about a week. TCE doesn't stick well to soil particles unless the soils have high organic carbon content. TCE is known to be only slightly soluble in water, but there is ample evidence that dissolved TCE remains in groundwater for a long time. Studies show that TCE in water will rapidly form a gas when it comes into contact with air. In a sand and gravel aquifer, TCE in the groundwater would rapidly vaporize into the air spaces between adjacent soil grains. Studies indicate that it would then disperse by two primary routes; first, diffusion through the soil air spaces and then be re-adsorbed by groundwater or infiltrating rainwater, or second, it would migrate as a gas to the surface and be released to the atmosphere. The primary means of degradation of TCE in groundwater is by bacteria. A breakdown product by this means is vinyl chloride (VC), a known human carcinogen (Vogel and McCarty 1985). However, VC has not, to date, been detected in either groundwater or soil gas at this site.

- Non-cancer Health Effects

In September 2011, the U.S. EPA published a reference concentration (RfC) of 0.37 parts per billion (ppb) for chronic (long-term) inhalation exposure to TCE. The RfC is based on decreased thymus weight in female mice and increased fetal cardiac malformations in rats, with uncertainty (safety) factors built in. The chronic RfC of 0.37 ppb for TCE derived by the U.S. EPA has now been adopted as the ATSDR chronic-duration inhalation MRL for TCE (ATSDR 2013). The effect level for fetal cardiac malformations, based on a human equivalent concentration (HEC) derived from rat studies, is 3.7 ppb for three weeks during pregnancy. At this concentration of TCE in air, a 1% response rate is expected for fetal heart malformations in humans. The effect level for TCE for immunological effects is 33 ppb. The human and animal studies of TCE and immune-related effects provide strong evidence for a role of TCE in autoimmune disease and in generalized hypersensitivity skin disorder, while the data for immunosuppressive effects is weaker. A supporting study of lower confidence indicated kidney effects at 5.6 ppb (U.S. EPA IRIS). The highest indoor air concentration of TCE detected in the residential neighborhood of the Valley Pike VOC site to date is 4.36 ppb, or about 10 times the RfC/MRL. The concentration of TCE in indoor air in one home is above the effect level for fetal heart malformations and may be a concern if there are any pregnant women in this home. Ten other homes have concentrations of TCE in indoor at or over 1 ppb, which suggests there could be other homes approaching the effect level for developmental, immune and kidney impacts. Again, this indicates that with additional sampling, more at-risk residences may be identified with elevated non-cancer risk from inhalation exposure to TCE.

- Cancer Risk

The U.S. EPA recently characterized TCE as *"carcinogenic in humans by all routes of exposure."* This conclusion is based on convincing evidence of a causal association between TCE exposure in humans and kidney cancer (U.S. EPA 2011). The International Agency for Research on Cancer (IARC) has recently classified TCE as carcinogenic to humans (Group 1) (Guha 2012). The National Toxicology Program (NTP) determined that TCE is "reasonably anticipated" to be a human carcinogen (NTP 2011).

Occupational exposure to high levels (greater than 100,000 ppb) of TCE in air, based on analyses of seven studies of worker populations, was associated with excess incidence of liver cancer, kidney cancer, non-Hodgkin's lymphoma, prostate cancer, and multiple myeloma in these workers. The strongest evidence for linking cancer in these workers to TCE exposure is for the first three of these cancers (NTP 2011). Agreement between human and animal studies supports the conclusion that TCE exposure may result in the development of kidney cancer. High doses are needed to cause liver toxicity and cancer in lab animals. Differences with regard to how humans and animals process TCE in the liver suggests that humans would be less susceptible to liver cancer from TCE exposures than the lab animals (NAS 2006).

The health effects, including increased cancer risks, from chronic exposure to low levels (single digit ppb range) of TCE in air and/or drinking water remain poorly-documented and largely unknown. ATSDR has recently derived a Cancer Risk Evaluation Guide (CREG) of 0.045 ppb for exposure to TCE over a lifetime. This represents an estimated contaminant concentration that

would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime.

The U.S. EPA recently updated its health risk assessment for trichloroethylene in September 2011 (U.S. EPA 2011). The inhalation unit risk (IUR) is 4.1 x 10^{-6} per µg/m^3 for combined target organ risk (kidney, liver, and non-Hodgkin's lymphoma), however target organ-specific unit risk can be determined for a more specific exposure scenario and the application of age dependent adjustment factors (ADAFs) for the contribution of the risk from kidney cancer. Using these values and the highest indoor air concentration of TCE (4.36 ppb = 23.4 µg/m^3) detected in a residence at the site, cancer risk from exposure to TCE was estimated. . We calculated cancer risk from TCE for the home with highest concentration of TCE (Table 1, Appendix A), which was approximately 1 possible excess cancer cases in a population of 10,000 over a lifetime of exposure. The actual or true risk is likely to be less because exposure is likely to be intermittent and less than a lifetime (70 years). The estimated cancer risk calculated for this site for lifetime exposure to TCE represents a moderate level of risk. However, this level of cancer risk slightly exceeds the lower boundary of the target cancer risk range (1 x 10^{-4} to 1 x 10^{-6}) typically used by the U.S. EPA.

Because the estimated cancer risk for people living in the home with the highest level of TCE (4.36 ppb) approaches 1 in 10,000, they have an increased risk for developing cancer during their lifetime due to exposure to TCE alone. The other 10 homes with TCE concentrations in indoor air above 1 ppb have a risk of additional cases above background of between 6.4 and 2.1 additional cases per 100,000 people, also indicating an increased cancer risk from TCE exposure.

Mixture Assessment-Evaluating combined exposure to PCE and TCE

- Combined Non-cancer Risk

Exposures to mixtures of both PCE and TCE are likely to be additive in nature in producing nervous system effects or non-cancer and cancer kidney or liver effects (ATSDR 2004). The non-cancer risk can be calculated using the hazard quotient (HQ). The HQ is the measured concentration divided by the chemical specific ATSDR minimal risk level (MRL) or U.S. EPA reference concentration (RfC).

Hazard Quotient formula:

$$HQ = \frac{\text{Concentration (ppb)}}{\text{MRL or RfC (ppb)}}$$

If the HQ for a chemical is equal to or less than one, it is believed that there is no appreciable risk that non-cancer health effects will occur. If the HQ exceeds one it does not mean harmful health effects will occur because of the margin of safety built-in to the calculation of MRLs and RfCs. The larger the HQ value, the more likely it is that an adverse effect may possibly occur.

The Hazard Index (HI) is the summation of HQ values for individual chemicals. Based on the highest concentrations detected for both chemicals in the indoor air as of February 2014, the HI

is estimated to be 193/6 + 4.36/0.4 = 32 + 11 = 43. For chemical mixtures with an HI greater than one, the estimated doses of the individual chemicals are compared with their no-observed-adverse-effect level (NOAEL) or the lowest-observed-adverse-effect level (LOAEL), the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

- Combined Cancer Risk

The combined cancer risk due to exposure to both PCE and TCE is estimated to be $3.4 \times 10^{-4} + 1.1 \times 10^{-4} = 4.5 \times 10^{-4}$ or about 4 to 5 in 10,000 in the home with the highest PCE and TCE concentrations. This level of cancer risk is above U.S. EPA's target cancer risk range—more than 1 additional cancer case from exposure to a chemical per 10,000 people. The estimated cancer risk calculated for this site is based on 70 years of exposure to a contaminant and represents a low to moderate level of risk. Four additional homes with elevated PCE concentrations also had TCE concentrations in indoor air above 1 ppb. When we consider the additive risk of residents living in these homes from PCE and TCE exposures, three of these additional homes have cancer risk that exceeds the target cancer risk range for U.S. EPA, at an additional cumulative risk above background of 2.6 to 3.7 additional cancer cases per 10,000 residents. As mentioned previously, if more data are collected in the community, it is likely that additional at-risk properties will be identified. Therefore, people may be at level of increased risk for developing cancer during a lifetime due to exposure to PCE and TCE that is considered unacceptable by the U.S. EPA.

CONCLUSIONS

1. A completed exposure pathway exists for the inhalation of indoor air contaminants via vapor intrusion. PCE and TCE have been detected in high concentrations in the groundwater, soil gas, sub-slab soil gas, and indoor air in and around homes to the west of the MRP facility, indicating that vapor intrusion is occurring or could occur. Only about half of the homes potentially impacted by contaminated groundwater have been sampled. Furthermore, many homes have only been sampled one time. Thus, there is a great deal of uncertainty regarding the true magnitude of exposure in the community. Sampling of additional homes is necessary to determine whether additional residents may be exposed to chemicals in their indoor air at levels that may pose a health concern.
2. Being exposed to the levels of PCE measured in some homes in the community could harm people's health. Levels of PCE in the indoor air of some home may put residents at risk for cancer (including bladder and liver cancer, non-Hodgkin lymphoma and multiple myeloma and non-cancer health effects (neurological).
3. Being exposed to the levels of TCE measured in some homes in the community could harm people's health. Potential adverse effects from breathing TCE include immunological effects, fetal heart malformations, kidney toxicity, and an increased risk of developing non-Hodgkin's lymphoma, liver and kidney cancer. Exposure to TCE in some homes poses a public health hazard.

RECOMMENDATIONS

ATSDR recommends the following:

1. Determine the full extent of the contaminant threat under the neighborhood by expanding the sub-slab and indoor air sampling in homes west and southwest of the likely source area on Valley Pike. In order to assess the public health implications of sampling results, detection limits below health comparison values are recommended.

2. Sample residences at risk of contamination via the vapor intrusion route.
    a. To adequately characterize resident exposure to indoor air contaminants from vapor intrusion, concurrently collect indoor air, ambient air, and sub-surface air (sub-slab soil gas or crawlspace) samples if possible.

    b. To characterize seasonal variability, sample collection during multiple seasons, including at least one sample during the winter months, is recommended.

    c. Include results for PCE and TCE degradation products cis 1,2-dichloroethene and vinyl chloride unless the investigation does not indicate their presence at this site at this time.

3. Mitigate the homes in the vicinity of the Valley Pike VOC plume that exceed health-based comparison values for PCE and TCE in order to reduce or eliminate ongoing exposures to elevated levels of PCE and TCE in the indoor air over the short term.

4. The detection limit for TCE is above ATSDR cancer risk values, its most conservative health based comparison value. Although it is appropriate for U.S. EPA to use detection limits

within their regulatory target risk range of a cancer risk between 10-4 and 10-6, ATSDR recommends the use of a lower analytical detection limit to better estimate the number of homes with indoor air levels posing an increased cancer risk.

5. Identify and mitigate or eliminate the source of the PCE and TCE in the groundwater contaminant plume that underlies the community in order to eliminate the threat to area residents over the long term.

PUBLIC HEALTH ACTION PLAN

1. The U.S. EPA plans to continue vapor intrusion sampling in the residential neighborhood to determine the full extent of the homes that may be impacted.

2. If sub-slab or indoor air screening levels for PCE or TCE is exceeded for a residential structure, the U.S. EPA plans to offer the installation a vapor abatement system (sub-slab depressurization system or SSDS) in the structure impacted by subsurface gas migration. They also plan to seal cracks in walls and floors of the basement and seal drains that could serve as entry points for soil vapors. The vapor abatement system will be designed to limit or reduce levels of VOCs to below ODH health-based sub-slab and indoor air screening levels.

3. For residential properties where a vapor abatement system has been installed, proficiency sampling will be conducted 30 days after installation to confirm that the contaminants of concern (PCE, TCE) are below levels of health concern.

4. Periodic inspections and O&M of vapor abatement systems will be completed at appropriate intervals and following site changes that could affect performance as long as the source remains above levels of concern.

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REPORT PREPARATION

This Public Health Consultation for this site was prepared by the Ohio Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner.

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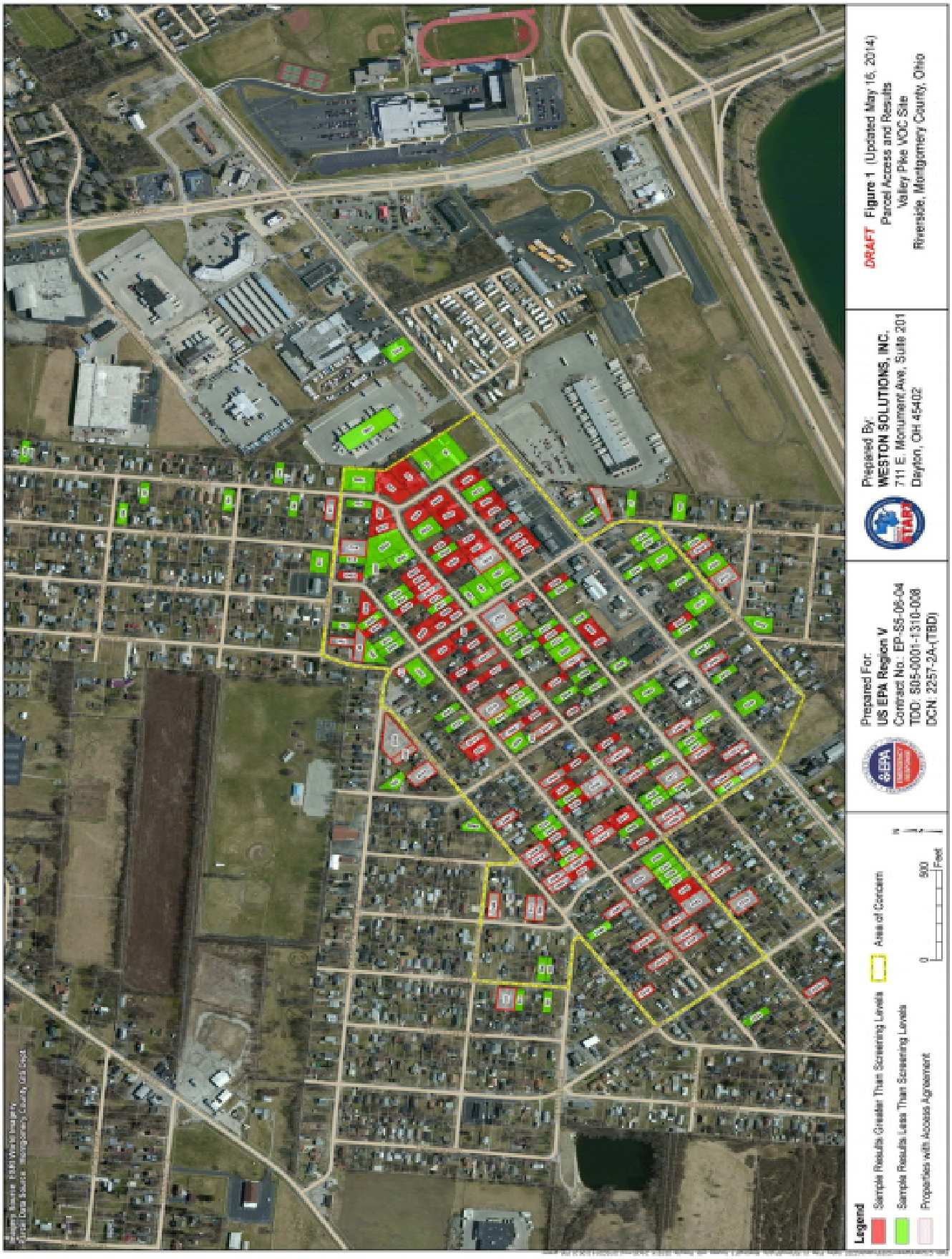
APPENDIX A: AERIAL FIGURES


DRAFT Figure 1 (Updated May 16, 2014)
Parcel Access and Results
Valley Pike VOC Site
Riverside, Montgomery County, Ohio
Prepared By:
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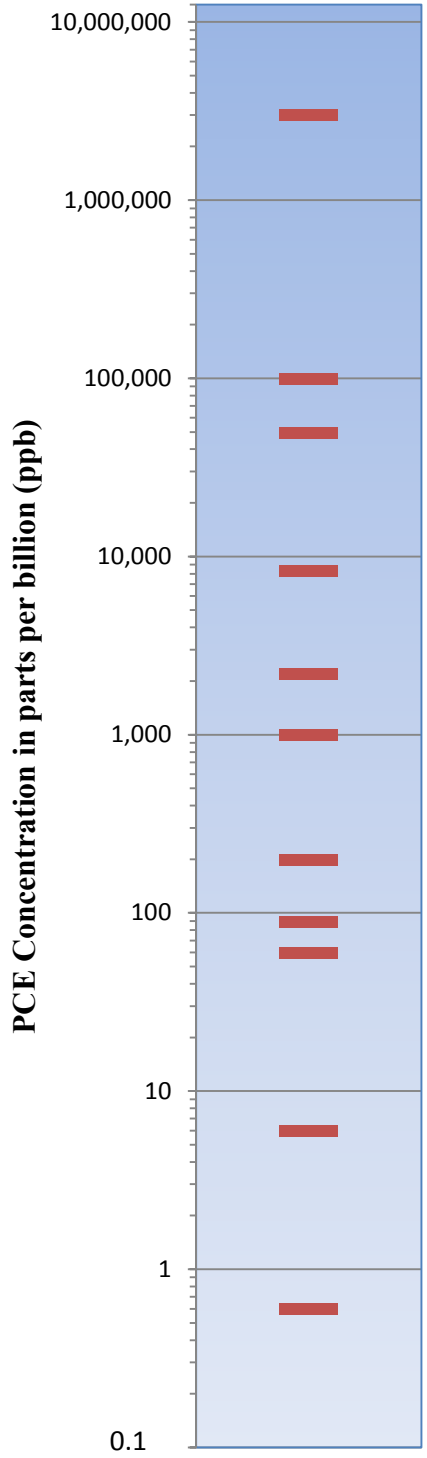
US EPA Region V
Contract No.: EP-S5-06-04
TDO: S05-0001-1310-008
DCN: 2257-2A-(TBD)
Legend
Sample Results Greater Than Screening Levels
Sample Results Less Than Screening Levels
Properties with Access Agreement
Area of Concern
0
900
Feet

Figure 2. Valley Pike VOC Site Groundwater Sampling Results

APPENDIX B. RISK FIGURES AND TABLE

Figure 1. Tetrachloroethylene (PCE) in Air: Health Effects and Guidelines



Death (mice & rats): 3,000,000 ppb

Acute Effects (humans): 100,000–200,000 ppb
(irritation of eyes, upper respiratory tract, and skin)

Acute Effects (humans): 50,000–300,000 ppb
(loss of coordination, dizziness)

Lowest Observed Adverse Effect Level (LOAEL): 8,300 ppb
(reaction time, cognitive effects)

LOAEL: 2,200 ppb (color vision)

Odor Threshold: 1,000 ppb

ATSDR Acute Minimal Risk Level: 200 ppb

→ **Maximum Indoor Air Concentration: 193 ppb**

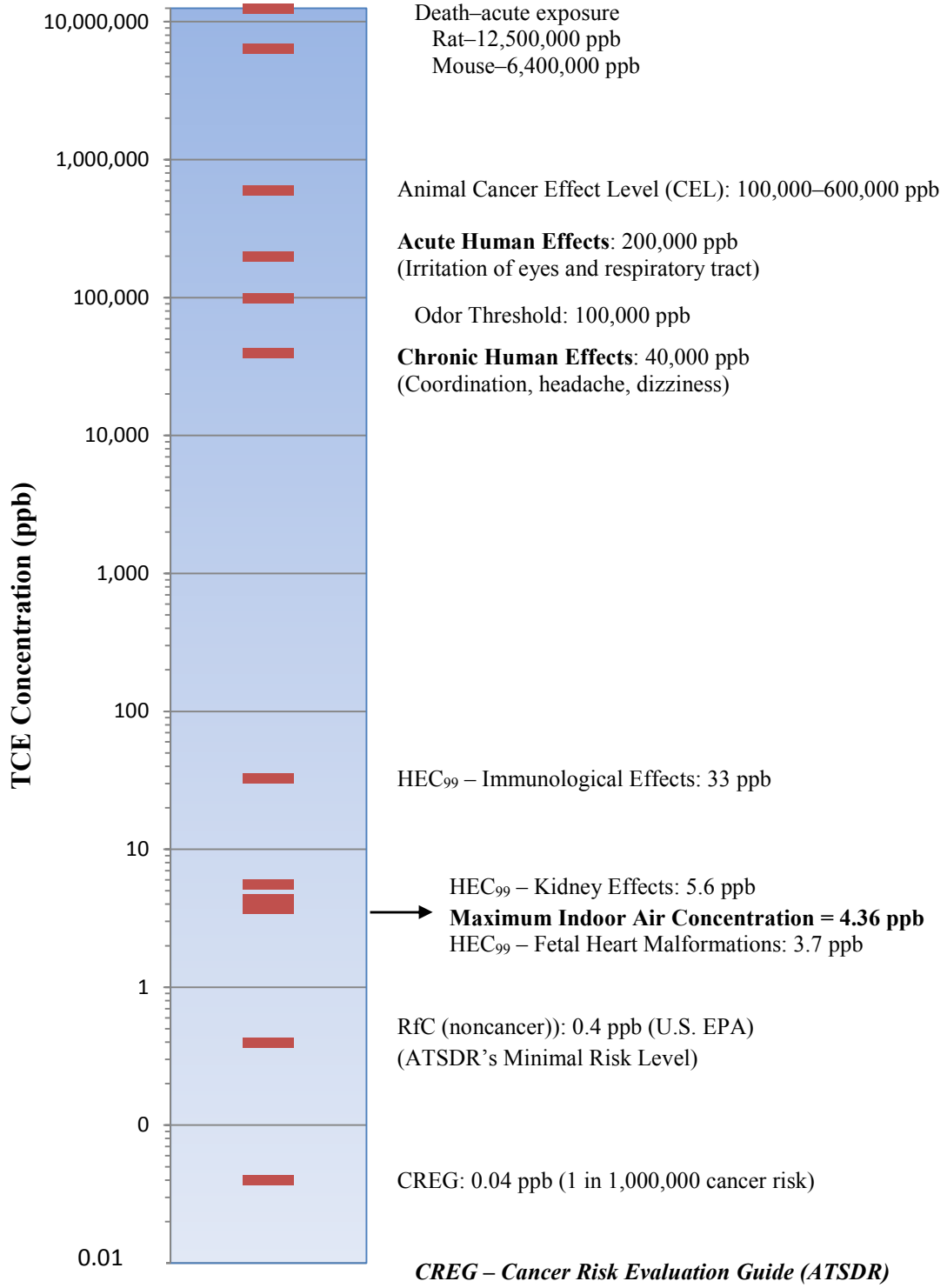
1 in 10,000 lifetime cancer risk: 60 ppb

1 in 100,000 lifetime cancer risk: 6 ppb;
RfC (noncancer): 6 ppb (U.S. EPA)

1 in 1,000,000 lifetime cancer risk: 0.6 ppb;
CREG: 0.57 ppb (ATSDR) (ATSDR)

CREG – Cancer Risk Evaluation Guide (ATSDR)
HEC – Human Equivalent Concentration
RfC – Reference Concentration (U.S. EPA)
ppb – parts per billion

Figure 2. Trichloroethylene (TCE) in Air: Health Effects and Guidelines (ppb)



CREG – Cancer Risk Evaluation Guide (ATSDR)
HEC – Human Equivalent Concentration
RfC – Reference Concentration (U.S. EPA)
ppb – parts per billion

Table 1. Age and target-organ adjusted cancer risk for TCE: Inhalation (concentration-equivalence across age groups)

Col A	Col B	Col C	Col D	Col E	Col F	Col G	Col H	Col I	Col J	Col K	Col L
	Exposure scenario parameters				Dose-response assessment calculations						
Units:		($\mu g/m^3$ air)	yr	-	$(\mu g/m^3 \text{ air})^{-1}$	-	-	$(\mu g/m^3 \text{ air})^{-1}$	$(\mu g/m^3 \text{ air})^{-1}$	-	-
Age group	risk per $\mu g/m^3$ air equivalence	Exposure concentration	Age group duration	Duration adjustment (Col D / 70 yr)	Kidney unadjusted lifetime unit risk	Kidney cancer default ADAF	**Kidney partial risk (Col B x Col C x Col E x Col F x Col G)**	Kidney+NHL+ liver unadjusted lifetime unit risk	NHL+ liver lifetime unit risk (Col I − Col F)	**NHL and liver partial risk (Col B x Col C x Col E x Col J)**	**Total partial risk (Col H + Col K)**
Birth to <1 month	1	23.43	0.083	0.0012	1.0E-06	10	**2.8E-07**	4.1E-06	3.1E-06	**8.6E-08**	**3.7E-07**
1 to <3 months	1	23.43	0.167	0.0024	1.0E-06	10	**5.6E-07**	4.1E-06	3.1E-06	**1.7E-07**	**7.3E-07**
3 to <6 months	1	23.43	0.250	0.0036	1.0E-06	10	**8.4E-07**	4.1E-06	3.1E-06	**2.6E-07**	**1.1E-06**
6 to <12 months	1	23.43	0.500	0.0071	1.0E-06	10	**1.7E-06**	4.1E-06	3.1E-06	**5.2E-07**	**2.2E-06**
1 to <2 years	1	23.43	1.000	0.0143	1.0E-06	10	**3.3E-06**	4.1E-06	3.1E-06	**1.0E-06**	**4.4E-06**
2 to <3 years	1	23.43	1.000	0.0143	1.0E-06	3	**1.0E-06**	4.1E-06	3.1E-06	**1.0E-06**	**2.0E-06**
3 to <6 years	1	23.43	3.000	0.0429	1.0E-06	3	**3.0E-06**	4.1E-06	3.1E-06	**3.1E-06**	**6.1E-06**
6 to <11 years	1	23.43	5.000	0.0714	1.0E-06	3	**5.0E-06**	4.1E-06	3.1E-06	**5.2E-06**	**1.0E-05**
11 to <16 years	1	23.43	5.000	0.0714	1.0E-06	3	**5.0E-06**	4.1E-06	3.1E-06	**5.2E-06**	**1.0E-05**
16 to <18	1	23.43	2.000	0.0286	1.0E-06	1	**6.7E-07**	4.1E-06	3.1E-06	**2.1E-06**	**2.7E-06**
18 to <21	1	23.43	3.000	0.0429	1.0E-06	1	**1.0E-06**	4.1E-06	3.1E-06	**3.1E-06**	**4.1E-06**
21 to <30	1	23.43	9.000	0.1286	1.0E-06	1	**3.0E-06**	4.1E-06	3.1E-06	**9.3E-06**	**1.2E-05**
30 to 70	1	23.43	40.000	0.5714	1.0E-06	1	**1.3E-05**	4.1E-06	3.1E-06	**4.2E-05**	**5.5E-05**
										Total risk:	**1.1E-04**

Note:
$\mu g/m^3$: micrograms of TCE per cubic meter of air
ADAF: age dependent adjustment factors
NHL: Non-Hodgkins Lymphoma